

The Impact of Sustainable Forest Management (SFM) Practices On Primary Timber-Based Production in Peninsular Malaysia

(Kesan Amalan Pengurusan Hutan Secara Mampan (SFM) Kepada Pengeluaran Produk Berasaskan Kayu di Semenanjung Malaysia)

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ABSTRACT

This paper investigates the impact of Sustainable Forest Management (SFM) practices on primary timber-based production in Peninsular Malaysia that is complying with the SFM practice scenarios. The Autoregressive Distributed Lagged (ARDL) Bounds Testing Approach have been used to analyze time series data from 1980 to 2012. Four scenarios were investigated: (i) 24% reduction in the harvested area, (ii) 25% increase in the domestic price of commodities, (iii) 47% increase in input costs, and (iv) a combination of Scenarios i, ii, and iii. The results reveal that sawn timber production is positively affected by the SFM practices; these practices vary between veneer and plywood production. Consequently, the producer can enhance sawn timber production after imposing the SFM practice scenario. The SFM practice scenario would generate the sustainable growth of the timber-based industry and help to enhance Peninsular Malaysia's forest conservation goals.

Keywords: Sustainable Forest Management Practices; Autoregressive Distributed Lagged (ARDL); sawn timber; veneer; plywood

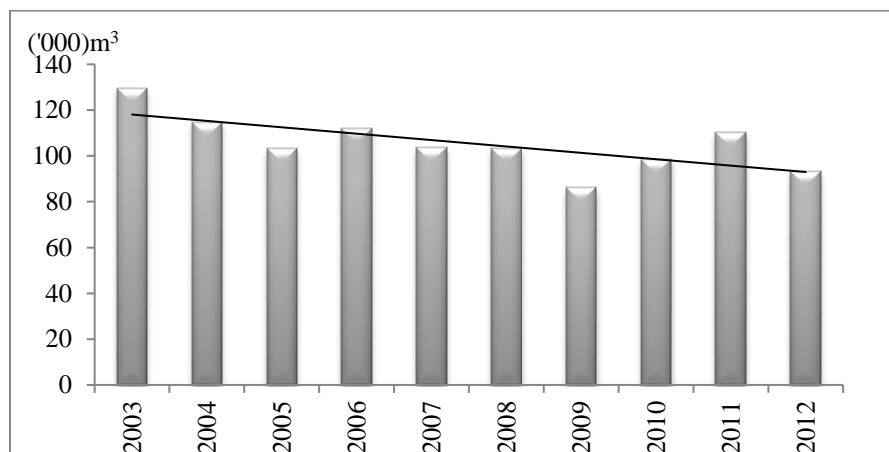
ABSTRAK

Kertas ini mengkaji kesana amalan Pengurusan Hutan Lestari (SFM) kepada pengeluaran produk berasaskan kayu utama di Semenanjung Malaysia yang mematuhi scenario amalan SFM. Pendekatan Ujian Pensempadanan (atau Batasan) Lat Tertabur Autoregresif (ARDL) telah digunakan untuk menganalisis data siri masa dari tahun 1980 hingga 2012. Empat scenario telah diasasat: (i) pengurangan 24% di kawasan yang dituai, (ii) peningkatan 25% dalam harga domestic komoditi, (ii) peningkatan 47% dalam kos input, dan (iv) kombinasi scenario i,ii,dan iii. Keputusan menunjukkan bahawa pengeluaran kayu gergaji adalah positif dipengaruhi oleh amalan SFM: amalan – amalan ini berbeza-beza antara venir dan pengeluaran papan ;apis. Oleh itu, pengeluar boleh meningkatkan pengeluaran kayu gergaji selepas mengenakan amalan scenario SFM. Senario amalan SFM akan menjana pertumbuhan industry berasaskan kayu secara mampan dan membantu meningkatkan matlamat pemuliharaan hutan Semenanjung Malaysia.

Kata kunci: Amalan lestari pengurusan hutan; Lat Tertabur Autoregresif (ARDL); kayu gergaji; venir; papan lapis

INTRODUCTION

Malaysia is a leading exporter of tropical timber and other timber-based products. Malaysia has also become a legacy of orderly growth, based on the sound foundation of environmental management. Hence, Malaysia has always subscribed to international best practices that ensure the protection and conservation of its environment. Malaysia has taken full responsibility by implementing Sustainable Forest Management (SFM) practices, instead of conventional timbering (CL), since 1990 (ITTO, 1990). Schwarzbauer and Rametsteiner (2001), state that the reductions in harvested areas, due to the application of certified forests, significantly impact the forest products market. However, the production cost increment for the installation and maintenance under SFM certification in the forest sector had small impacts and did not reduce the harvested area. Figure 1 illustrates that the areas licensed for harvesting in Peninsular Malaysia have decreased since 2003.



Source: Forestry Statistics Peninsular Malaysia (2012).

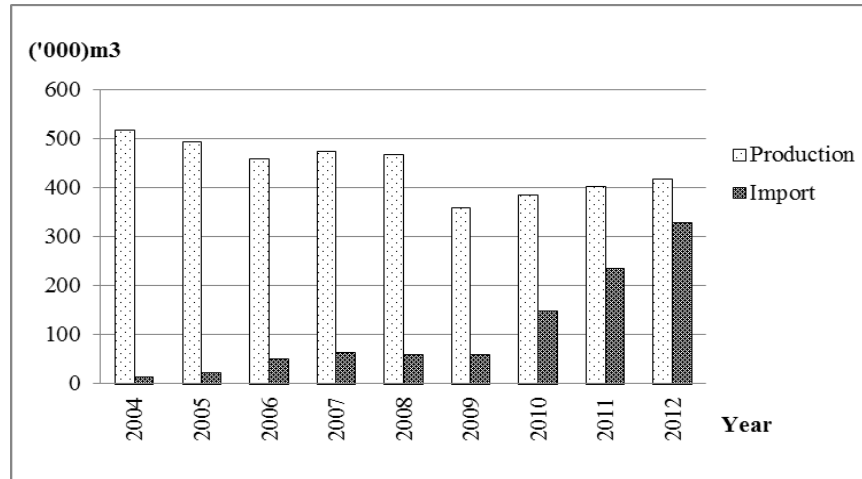
FIGURE 1. Forest area licensed for harvesting in Peninsular Malaysia

FDPM (2012) illustrated that primary timber-based production decreased 25% in 2012, due to a raw materials shortage. Primary timber-based products refer to sawn timber, veneer and plywood, where timber is the primary raw material. When the number of products decreases, so does the concessionaire's profit. Maser (1997) estimated timber harvesting criteria and indicator compliance at USD2.2 million annually (RM7.85 million annually). In Malaysia, the cost of improving forest harvesting operations from current practices to a certifiable level could exceed the current costs by 62.5% (Thang 2003). The increase in the Malaysian Criteria & Indicators (MC&I) cost compliance in forest harvesting will affect the feasibility of the long-term management of forest concessions. In the long-run, timber-based product prices will also be affected.

As mentioned earlier, in order to achieve SFM, there is a need for substantial reduction in the annual coupe or allowable cutting rate in the country. In the recognition to the need of strengthening SFM practices, Malaysia has undertaken a critical step to reduce the annual coupe or AAC in the country (Woon & Tong 2004). Other than reducing AAC, the stringent criterion of SFM is by harvesting operations that have affected the timber volume which can be extracted. In addition, Peninsular Malaysia has banned the timber export since 1990s. Worst come to worst, the accessible forestland in Malaysia has slowly given way to agriculture especially in oil palm plantation, new satellite towns and other forms of land use, simultaneously creates a conflict between agriculture production and forest management (Ahmad Fauzi et al. 2010). As a result, it has affected the supply of Malaysian timber which represents the raw material for primary timber processing (Abdul Rahim & Mohd Shahwahid 2009).

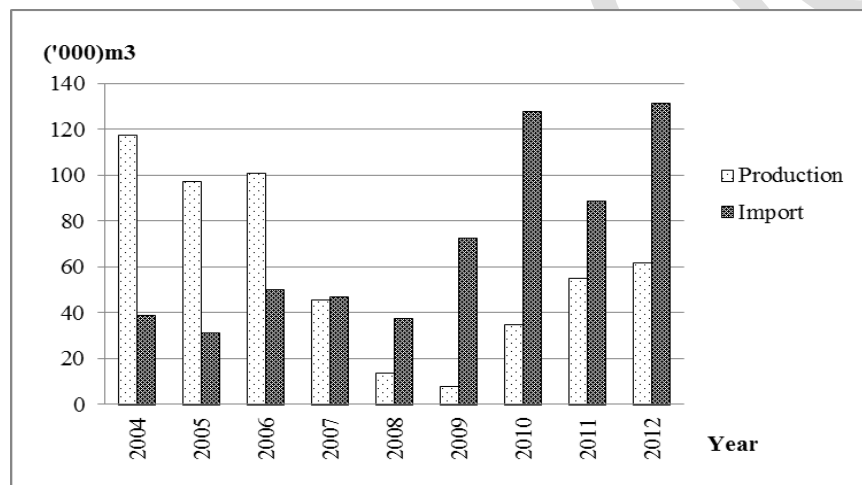
According to Anon (2008), the declination of timber supply and high demand to utilize intermediate products for further value-added downstream processing gave an impact towards the exportation of sawn timber and veneer. In 1999, the export of sawn timber and veneer decreased by average annual rates 1.4 percent and 3.1 percent, respectively due to the reasons mentioned above. Furthermore, Norini (2001) stated that in late 1990s, timber-based industry in Malaysia moved from producing products such as timber, sawn timber and plywood/veneer to manufacturing high value-added products like furniture, joinery/mouldings and rubber wood products. In this context, it creates further shortage towards the supply on primary timber-based products as raw materials especially in meeting the demand of the local secondary timber processing mills.

The effect on timber markets due to the compliance with SFM practices is still open for debates. The capability of forest plantation to support our local timber industry is limited as the availability of land is not adequate enough especially in Peninsular Malaysia. The producer needs to import internationally due to national supply issues. Figures 1(A) and 1(B) show the historical data for the production and importing of plywood and veneer, respectively, for mill consumption. Plywood and veneer production decreased from 2004 to 2012, and *vice versa*. Hence, imported plywood and veneer is needed to fulfil the consumption.



Source: Forestry Statistics Peninsular Malaysia (2012)

FIGURES 1(A). Total production and import of plywood



Source: Forestry Statistics Peninsular Malaysia (2012)

FIGURES 1(B). Total production and import of veneer

The hypothesis of the study is we believe SFM practices have positive impact toward the growth rate of timber-based industry in Peninsular Malaysia. The study on the primary timber-based industry is crucial in the situation where Malaysia is now complying with SFM practices and facing a shortage of timber supply as raw material for sawmills. This study attempted to determine the determinant of the supply of primary timber-based products and forecast the impact of SFM practices incorporate with several scenarios under SFM practices in Peninsular Malaysia.

LITERATURE REVIEW

Malaysia was registered into International Timber Trade Organization (ITTO) since 1990 (Samsudin & Heyde 1995). Being registered under one of the ITTO members therefore has to agree to strive for an international trade of tropical timber from sustainably managed forests. This commitment became popular in the Year 2000. However, while recognizing this lack of progress, ITTO members restated their commitment to move as rapid as possible towards achieving exports of tropical timber and timber products from sustainably managed sources and renamed this commitment as "ITTO Objective 2000".

Malaysia is known as the consumers and producers of timber-based products of Sustainable Forest Management (SFM) practices. According to ITTO (1992), SFM practices can be defined as:

“The process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment.”

From the definition above, all forest-related activities should not cause damages to the forest to the extent that its capacity to deliver products and services such as timber, water and biodiversity conservations are significantly being reduced. Forest management should also aim to balance the needs of different forest users so that its benefits and costs are shared equitably.

This action is designed to assist Malaysia as one of the tropical countries to manage and conserve the resource base for tropical timber. It embraces several aspects of SFM such as planning, reducing impact logging, community forestry, fire management and biodiversity and transboundary conservation (ITTO 1992). Thus, Malaysian forest resources are carefully managed according to the principle of SFM practices to achieve balance between development and conservation. Thus, the timber-based products and services can be obtained in perpetuity. In order to ensure a continuous supply of timber for timber-based production, harvesting is regulated by area control and volume method which are prescribed in the management plans. The National Forestry Council allocates an annual felling coupe to each state based on forest inventory data, net area of production forest and silvicultural practices in place. These practices are revised from time to time to meet prevailing challenges and requirements and to improve the management, conservation and sustainable development of natural forests and timber-based products in Malaysia.

Some studies believed that the positive effects of SFM practices were likely to be significant in the long-run. The positive impact could be viewed from a study done by Kumari (1996). Although SFM practices suffered social efficiency related to the timber-based products, the government imposed ban on timber-export Peninsular Malaysia in 1985. Therefore, this action stimulated timber processing and provided opportunities for high value added products to increase export and employment opportunities. In the issue of timber production, Thang (2003) stated that the total timber production in Malaysia was expected to increase up till 32.47 million m³ by 2020. In Finland, Lepannen et al. (2005) found that negative short run impacts of conservation on timber will be compensated in the long run by intensified use of the remaining timber stock. But, Abdul Rahim and Mohd Shahwahid (2009) found that short run analysis revealed positive impacts of SFM practices on timber supply. However in the long run, the findings indicated substantial reduction in timber supply due to SFM practices.

Kleine and Heuveltop (1993) show that only mature trees greater than 60 cm in diameter should be harvested as good quality timber. Once the government changed conventional logging (CL) practices to SFM practices to manage the natural forest, the equilibrium quantity of timber has decreased. This resulted in less timber being available for primary timber processing (Mohd Shahwahid, 2006). Consequently, the timber price increased, which increased the operational cost of primary timber processing. This result concurs with Abdul Rahim et al.'s (2012) findings: to offset operational costs, producers must increase the price of primary timber-based products. Since the 1990s, the timber shortage has resulted in a decrease in primary timber processing production. The shortage of timber has also led to an increase in local demands for high value-added manufactured goods, as well as the obligations of SFM practices (Ahmad Zuhaidi et al. 2007; Norini 2001).

In Indonesia, Menurung (1995) stated that the timber export ban policies had indeed promoted the development of plywood and sawn timber. While in terms of revenue, the country would have been better off without the ban. Revenue increased from exporting more plywood and sawn timber were less than the losses in the timber exports. But, in Japan, Southeast Asia gave timber export restrictions toward Japan and it gave high impact towards their plywood markets. Tachibana (2000) stated that in the raw timber market, both surpluses of producers and consumers were decreased. While in the plywood market, the producer surpluses in Southeast Asian countries increased and consumer's surplus in Japanese plywood market increased. Woon (2001) studied on the impacts of Sustainable Forest Management (SFM) practices on the timber-based industries in Peninsular Malaysia and found out that the total number of mills in the timber-based industry was expected to be drastically reduced within the next 5-7 years because of SFM practices. Also, it would become worse and would be losing in the employment and forest revenue. According to Schwarzbauer and Rametsteiner (2001), the reductions in harvested area due to the application of certified forest gave a larger impact to the forest product market. However, the increment of production costs for installation and maintenance under SFM certification in the forest sector gave small impacts rather than reducing in harvested area.

Awang Mohdar and Ahmad Zuhaidi (2005) stated that in spite of the high demand of timber in worldwide setting and the upsurge of price throughout the years, forest plantations in Malaysia are developing at a very slow pace. So, this issue is still being debated between the SFM and timber-based industry. However, in order to penetrate international markets, timber-based products need to be certified beforehand. According to Baharuddin and Simula (1996), timber certification is the written result on the quality statement (a certificate) attesting the origin of timber raw material and its status and qualification follow validation by an independent third party. However, Chew et al. (2001) reviewed it as a means of communication between

producers and consumers to make up two components which are forest management certification and chain-of-custody or products certification. Both producers and consumers play an important role to ensure the timber to gain recognition in the international markets. In addition, Mohd Shahwahid (2006) stated that certifications were very important in order to make sure timber-based products to have a market driven to international markets. At the same time, this has become a tool to promote Malaysian forest by sustainable forest management. However, this is not the work of one individual only. Collaborations among various parties including national and international NGOs, governmental agencies, and international markets have a significant and strong role in strengthening their domestic support for certification.

Based on previous studies, there are positive and negative effects toward the implementation of SFM practices. However, due to the efforts in achieving a balance between development and conservation, this is the starting point towards sustainability. Few plans such as products and diversification, rationalization in timber-based industry, switch to other material as a substitute to the raw material and importation of material for production of furniture and fixtures domestically (Norini 2001) can be the efforts to reach the sustainability of timber-based industry in Malaysia.

METHODOLOGY

This study employed annual data from 1980 through 2015 entered into an Excel spreadsheet. Data were obtained from the Forestry Statistics Peninsular Malaysia and World Development Indicators 2012 (WDI). Econometrics (EViews7) was used to analyze the Peninsular Malaysia timber-based production model. This study holds the law of supply states other things remaining the same, the higher the price of a good, the greater is the quantity supplied; and the lower the price of a good, the smaller is the quantity supplied. The law of supply results from the general tendency for the marginal cost of producing a good or service to increase as the quantity produced increases. In the other word, producers are willing to supply a good only if they can at least cover their marginal cost of production (Mankiw 2014)

Kumar (1981, 1983) recommended expected variable signs using econometric theory: positive signs for the production of timber-based products, the technology and harvesting area, and the income variables (i.e., domestic and foreign), showing that if these values increase, then the general demand for timber-products will also increase. A negative sign is expected for the price of timber-based products and the input costs.

MODEL ESTIMATION

The production models are specified as:

$$TSB_t = \alpha_0 DB_t^{\alpha_1} AH_t^{\alpha_2} WB_t^{\alpha_3} \quad (1)$$

$$\ln TSB_t = \alpha_0 + \alpha_1 \ln DB_t + \alpha_2 \ln AH_t + \alpha_3 \ln WB_t + \varepsilon_t \quad (2)$$

Where: TSB_t =total production of sawn timber, DB_t = domestic price of sawn timber, AH_t =harvested area in the natural forest, WB_t = total wages paid in sawmills, t = years, ε_t = error term and \ln is the natural logarithm. The original sawn timber production model in Equation (1) can be transformed with a log linear form. Equation (2) estimates the total production of sawn timber. This approach is the same for all models in this study. The model is applied to veneer and plywood as the production of veneer (TSV_t) and the production of plywood (TSP_t). The adjustment variable to DB_t replaces the price of veneer (DV_t) and price of plywood (DP_t). WB_t replaces WP_t as veneer and plywood that comes from the same mills.

Other than that, this model is being applied to veneer and plywood as supply of veneer (TSV_t) and supply of plywood (TSP_t). The adjustment variable to DB_t replaces price of veneer (DV_t), price of plywood (DP_t), and WB_t replace WP_t as veneer and plywood which come from the same mills.

THE AUTOREGRESSIVE DISTRIBUTED LAGGED (ARDL) BOUNDS TEST

The ARDL approach involves estimating the error correction version of the ARDL model for variables under the estimation (Pesaran et al. 2001). The ARDL model for production can be written as:

$$\Delta L TSB_t = \alpha_0 + \gamma_1 L TSB_{t-1} + \gamma_2 L DB_{t-1} + \gamma_3 L AH_{t-1} + \gamma_4 L WB_t + \sum_{i=1}^p \beta_{1i} L TSB_{t-i} + \sum_{i=0}^p \beta_{2i} \Delta L DB_{t-i} + \sum_{i=0}^p \beta_{3i} \Delta L AH_{t-i} + \sum_{i=0}^p \beta_{4i} \Delta L WB_{t-i} + \mu_t \quad (3)$$

Where: Δ = difference operator; p = lag order; and ε_t = assumed serially uncorrelated. Eq. (3) is the error correction version related to the ARDL, since the terms with the summation signs (\sum) represent the short run dynamics. The second part (term with μ 's) corresponds to the long run (cointegration) relationship. The null hypothesis in Eq. (3) is defined as $H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$, indicating the non-existence of the long run relationship.

Furthermore, ∂ECM_{t-1} is the error correction term defined as:

$$\partial ECM_{t-1} = LTSB_t - \alpha_0 - \sum_{i=1}^p \omega_{1i} LTSB_{t-i} - \sum_{i=0}^p \alpha_{1i} \Delta LDB_{t-i} - \sum_{i=0}^p \alpha_{2i} \Delta LAH_{t-i} - \sum_{i=0}^p \alpha_{2i} \Delta LWB_{t-i} + \mu_t \quad (4)$$

After estimating the long-run coefficient of the variables, Error Correction Model (ECM) was estimated to determine the existence of the long-run relationship. ECM acted as a measurement for the speed of adjustment. It happened when the dependent variable adjusted to change in the independent variables before converging to the equilibrium level. In this case, the speed of adjustment for short-run to reach the long-run equilibrium is represented by ∂ . The sign of α coefficient shows the long-run relationship. The null hypothesis is ($H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$).

SCENARIO IMPLEMENTATION

The forecast of exogenous variables is the baseline. All forecasted exogenous variables (baseline) have 4 scenarios imposed:

- 1) 24% reduction in harvested area
The percentage of reduction in harvested area was adapted from a study conducted by Ahmad Fauzi et al. (2002). This scenario reflected the foregone revenue from buffer areas. The buffer areas referred to riverine areas and steep areas. The licensee contractors and harvesting crews were also incurred an opportunity cost from unearned timber income from buffer areas. Under Conventional Practices (CP), the forgone revenue from buffer areas only took 5.19% with RM216.26/ha. However, Malaysian criteria and indicators (MC&I) for SFM practices took 24.33% with RM2,065.60/ha. This forgone revenue included timber revenue incurred by the licensee and loss of royalty charges which were not collected by the Government. By referring to the impacts of implementing SFM practices on timber harvesting (timber as raw material for primary timber-based products processing), a reduction by 24% in harvested area was taken as Scenario 1.
- 2) 25% increase in domestic price
This scenario reflected the domestic price market in Peninsular Malaysia by assuming that the domestic price might fetch price premium. In other words, these simulated prices were the price of timber when best practice environmental resource management was adapted and when price distortion was remedied. According to Baharuddin (1995), Baharuddin and Simula (1996) and Oliver (2005), they claimed that consumers in Europe and United States of America (USA) were willing to pay from 2 to 30 percent more for sustainably produced certified tropical timber. However, based on a study done by Kollert and Lagan (2007), they found out that Sabah timber achieved a price premium for high quality hardwoods fetch a price premium of 27% to 56%. Lower quality timbers also fetch a price premium; however the difference is less pronounced (2% to 30%). They carried out their study in selected Forest Management Units (FMUs) in Sabah, Malaysia. So, for this scenario, the researchers of the present study take into account by imposing 25% of increasing of domestic price in average by range of 2 to 56 percent.
- 3) 47% increase in input costs
This scenario reflected the implementation of Sustainable Forest Management (SFM) practices toward forest areas. It became adverse effect towards the profitability on the practices of Sustainable Forest Management (SFM). This scenario was borrowed from Abdul Rahim et al. (2009). They found out that the cost of implementation of Sustainable Forest Management (SFM) practices by using logging methods namely 'Logfisher' was higher than conventional logging method. The incremental average per ha total cost rose by 46.8% to RM13,573/ha. Wages was referred as the input cost in this study and it imposed rise by 47%.
- 4) Integration of Scenarios 1, 2 and 3
This scenario incorporated Scenarios 1, 2 and 3.

RESULTS AND DISCUSSION

The result will be a discussion on the estimation of ARDL procedure followed by the forecasting process. This includes the results on the stationarity test which was performed to the variables; ADF unit root test and Phillip-Perron unit root test. The co-integration test was estimated and the results of the estimated models of the ARDL will be presented and discussed. Finally, diagnostic tests were conducted to test the consistency and compatibility of the estimated model. While, continue to the forecasting using coefficients (elasticities) was conducted for the period of 2015 to 2020.

UNIT ROOT TEST

Two unit root Augmented Dickey and Fuller (ADF) and Phillips and Perron (PP) tests were conducted to determine the order of integration of the series. Based on Table 1, most variables were stationary in the first difference at the 1% significance level and non-stationary in levels. All series appeared to be stationary after first differencing (i.e., I(1)).

TABLE 1. Unit Root test

	Augmented Dickey Fuller (ADF)		Phillips Perron (PP)	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
	Level			
LHA	-1.101416	-13.31621***	-2.909449**	-11.87045***
LDB	-0.440943	-2.796481	-1.774643	-2.888236
LDV	-1.903263	-2.133975	-1.782858	-2.116622
LDP	-1.508644	-2.148476	-1.504595	-2.216308
LTSB	-1.774643	-2.796481	-1.774643	-2.888236
LTSV	-1.545667	-3.144410	-1.464993	-2.281180
LTSP	-3.014460**	-2.471487	-2.997489**	-2.478659
LWB	-4.975479***	-5.011444***	-4.975479***	-5.01144***
LWP	-3.035647**	-3.170889	-3.040519**	-3.243938*
	First Difference			
LHA	-7.958220***	-7.810621***	-40.52229***	-38.72472***
LDB	-5.947991***	-6.223817***	-5.931779***	-5.931779***
LDV	-5.352326***	-5.416983***	-6.441175***	-10.61409***
LDP	-6.196741***	-6.268812***	-6.196741***	-6.268812***
LTSB	-5.947991***	-6.223817***	-5.931779***	-5.931779***
LTSV	-4.626369***	-4.542183***	-4.903939***	-4.578257***
LTSP	-6.152166***	-6.559799***	-6.157193***	-7.192378***
LWB	-7.071785***	-7.449866***	-20.83005***	-31.09326***
LWP	-9.779441***	-9.653651***	-9.993371***	-9.864827***

Note: ***, ** and * denotes significant at 1%, 5% and 10% significance level, respectively.

TIMBER-BASED PRODUCTION MODEL ARDL RESULTS

Table 2 illustrates that the F-statistics for each commodity were 5.560 (sawn timber) at 5%, 5.613 (veneer) at 5% and 9.423 (plywood) at the 1% significance level. Hence, all models were co-integrated and validated a long-run relationship among the variables.

TABLE 2. Cointegration test

Market Model	Lagged structure	F-statistic	Significance level	Bound critical values ^a (unrestricted intercept and no trend)	
				I(0)	I(1)
Sawn timber (LTSB)	(1,0,0,1)	5.560**			
Veneer (LTSV)	(1,2,2,0)	5.613**			
Plywood (LTSP)	(1,1,0,1)	9.423***			
			1%	5.333	7.063
			5%	3.710	5.018

10% 3.008 4.150

^aBased on Narayan (2005).

Table 3 presents the econometric diagnostics. Among the production commodities models, the harvested area (LHA) for the production of sawn timber (LTSB) was highly significant (5%) (elastic). The harvested area (LHA) for the other production commodities models (veneer and plywood) was not significant towards their models (LTSV and LTSP, respectively). The harvested area (LHA) had significant determinants on the production of sawn timber (LTSB). This is a direct impact of timber harvesting activities as raw materials in sawn timber making. Sangkul (1995) revealed that 51% of sawn timber was recovered from 20-year-old teak tree plantations with a diameter of 9-20.5 cm in Thailand. By improving Teak tree silvicultural activities, the sawn timber recovery for timber ranged from 66.8% to 77.8% (Thulacidas & Bhat 2009). Jamal and Mohd Shahwahid (2006) mentioned that timber production started to decline in 1992, due to SFM practices. As a result, harvested area became a production determinant of sawn timber.

TABLE 3. ARDL coefficient for long-run elasticity

Dependent variable	Independent Variables	Coefficient	t-Statistic (P-value)
Sawn timber LTSB _t (1,0,0,0)	LDB _t	0.333	1.070[0.292]
	LHA _t	1.273**	2.133[0.040]
	LWB _t	-0.015	-0.360[0.721]
	Constant	0.580	-0.244[0.809]
Veneer LTSV _t (2,0,0,0)	LDV _t	1.513***	4.208[0.000]
	LHA _t	0.657	1.460[0.153]
	LWP _t	-0.877**	-2.249[0.031]
	Constant	0.705	0.079 [0.937]
Plywood LTSP _t (1,2,0,0)	LDP _t	1.513***	4.208[0.000]
	LHA _t	0.657	1.460[0.153]
	LWP _t	-0.877**	-2.249[0.031]
	Constant	0.705	0.079 [0.937]

Notes: P-value for diagnostic test in parentheses [...]. ***, **, and *, represent significant at 1%, 5%, and 10%, respectively.

Harvested area (LHA) was not significant towards the production of veneer (LTSV). Dobner et al. (2013) reported an average recovery rate of veneer at 54% of increasing recovery, with an increment on the log small end diameter. The log small end diameter refers to the smallest diameter of the log which produces smaller amounts of yields. The recovery rate depended on the size and quality of logs. Big logs had a higher volume of peeled veneer. Harvested area (LHA) was not significant in influencing plywood production, due to plywood being a combination of odd numbers of veneer.

The domestic price of sawn timber (LDB) and veneer (LDV) was not a significant determinant of production. This result contradicted Hashim (1998). According to Ariffin (1994), who studied the production and demand relationships for hardwood timber in Indonesia, they found that timber price influenced hardwood timber production. Domestic price (LDP) was significant at 1% and elastic for the plywood production model (LTSP). Hence, domestic price (LDP) became a significant determinant of plywood production (LTSP). The results for the domestic price of plywood (LDP) suggested that there was a 10% increase in growth in average LDP, *ceteris paribus*; the average production of plywood (LTSP) increased at a rate of 1.5% annually. The significant coefficient of LDP verified the priori assumption that price was an incentive for plywood production.

The input cost of plywood (LWP) was significant at 5% (inelastic) with a negative coefficient. As such, a 10% increase in input cost of plywood (LWP), *ceteris paribus*, would lead to a decrease in plywood production (LTSP) at a rate of 0.7%. In this situation, the input cost (wages) represented the production cost of plywood incurred by producer in plywood mills. A large LWP value would reduce the volume of plywood produced.

Based on Table 4, the ECM_t for supply model of sawn timber, veneer and plywood were significant at 5%, 1% and 5% respectively which could be concluded that the short-run relationship existed among the variables. The estimated coefficient of ECM_t for supply model of sawn timber, veneer and plywood were -0.236, -0.420 and -0.377 correspondingly.

The results suggested that, convergence to equilibrium of all independent variables for total supply for each commodity in one year was corrected for about 23.6%, 42.0% and 37.7% respectively in the next year.

TABLE 4. Error Correction model

	Dependent variable	Independent Variables	Coefficient [t-statistic]
Sawn timber	ΔLTSB_t	ΔLDB_t	0.079[-1.137]
		ΔLHA_t	0.301**[2.504]
		ΔLWB_t	-0.004[-0.356]
		Constant	-0.519[0.253]
		$\text{ECM}_t(-1)$	-0.236**[-3.325]
Veneer	ΔLTSV_t	ΔTsv_t	0.388*[2.032]
		ΔDV_t	0.440[1.244]
		ΔHA_t	0.987[1.327]
		ΔWP_t	-0.180[-0.188]
		Constant	-6.621[-0.451]
		$\text{ECM}_t(-1)$	-0.420***[-2.878]
Plywood	ΔLTSP_t	ΔDP_t	0.449*[1.841]
		$\Delta\text{DP}_t(-1)$	-0.511**[-2.300]
		ΔHA_t	0.247[1.546]
		ΔWP_t	-0.330*[-1.764]
		Constant	0.265[0.079]
		$\text{ECM}_t(-1)$	-0.377**[-3.341]
		Diagnostic Test	
Type of Test	Sawn timber	Veneer	Plywood
LM test	0.074[0.788]	0.542[0.469]	0.119[0.732]
Breuch-Pagan	0.121[0.730]	8.662[0.123]	0.808[0.374]
Ramsey RESET test	0.078[0.782]	0.5833E4[0.994]	0.212[0.648]
R-Squared	0.8534	0.8053	0.8583
Cusum test	Stable	Stable	Stable
Cusum Square test	Stable	Stable	Stable

Notes: ***, **, and * represent significant at 1%, 5%, and 10%, respectively.

PRODUCTION TIMBER-BASED PRODUCT FORECASTING

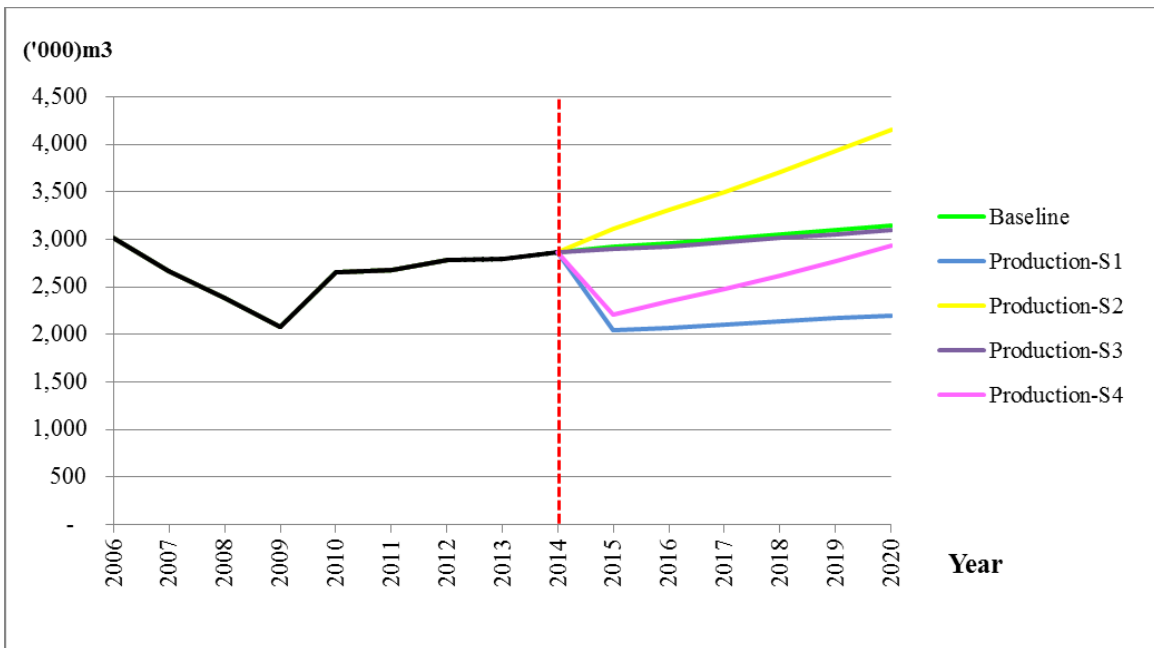
Each exogenous variable for each commodity is forecasted for 5 years, annually from 2015 until 2020. Based on the historical data plot from 2006 to 2015, the fluctuation trend, especially in 2008, was the result of the 2008 global economic downturn (Amoah et al. 2009). Hence, discussions will focus on the impact of SFM practices for sawn timber, veneer and plywood.

SAWN TIMBER

Figure 2 illustrates that sawn timber production increased annually until 2014. Once the scenario is imposed in 2015 (starting from the red boundary line), the production forecast line for the baseline (light green line), Scenario 2 (yellow line) and Scenario 3 (purple line) show an increasing trend. However, the supply forecast line for Scenario 1 (blue line) and Scenario 4 (pink line) show a decreasing trend at first 2014-2015 and just after showing increasing trend to the years ahead.

In 2016, all forecast lines show an increasing trend. Each forecast line represents each scenario, which shows an increasing trend; however, the forecast line that (S4) incorporates 3 scenarios (pink line) yields better results than the other two

scenarios and the baseline. In reality, the policy involves a combination of a few scenarios. From that, each scenario can be seen as the offset of each scenario to obtain the best forecasted result.

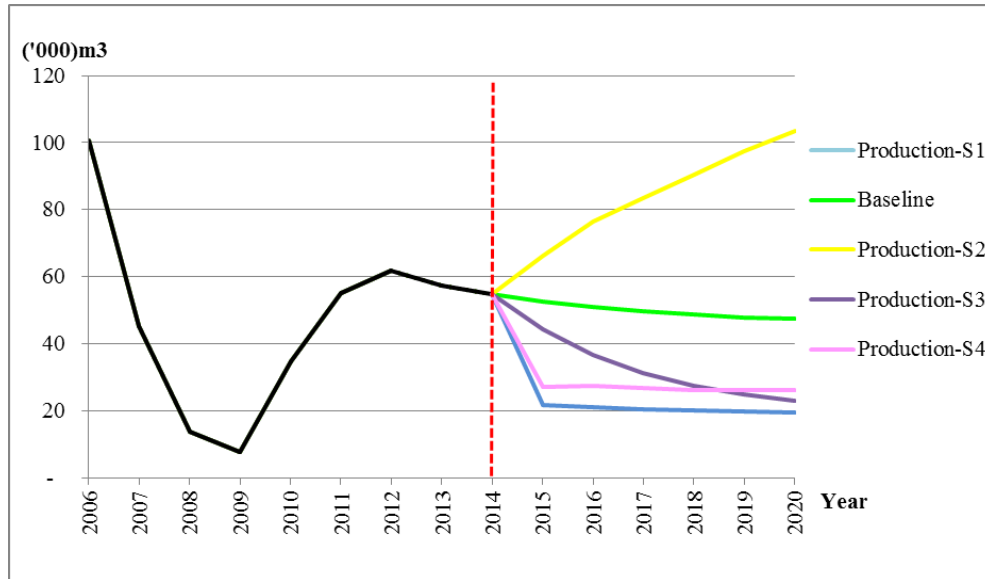


Notes: The vertical line refers to the threshold between the historical and forecasted data.

FIGURE 2. Forecasting results on sawn timber production

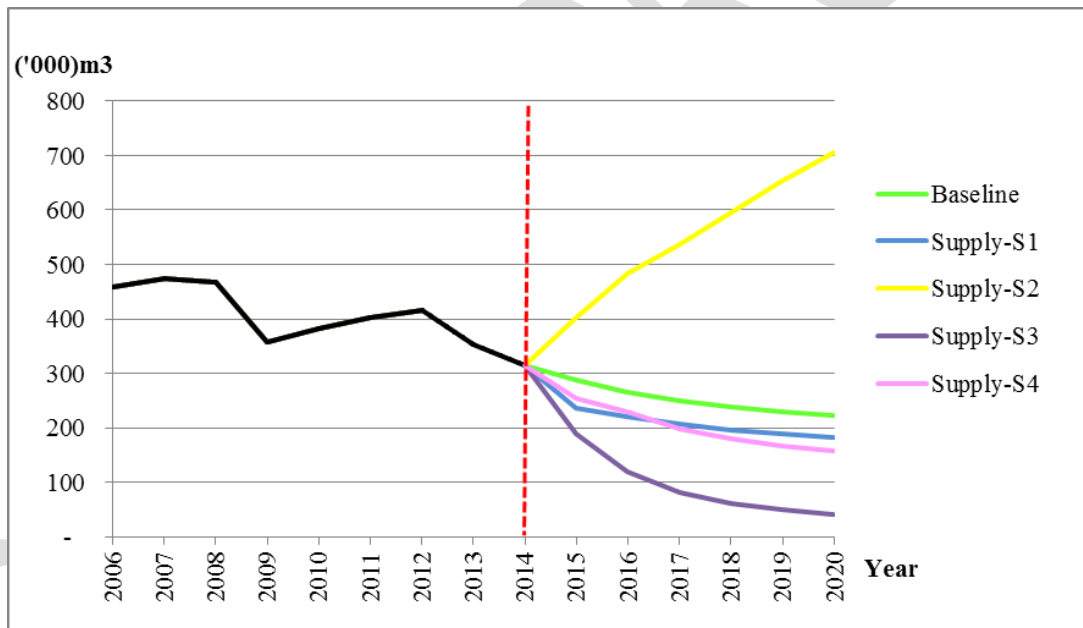
VENEER AND PLYWOOD

Figures 3 and 4 illustrate that the production of veneer and plywood forecast line under Scenario 2 (yellow line) showed an increasing trend. The other four lines, including the baseline (green line), Scenario 3 (purple line), Scenario 1 (blue line) and incorporating 3 scenarios (light blue line) showed a decreasing trend. Only Scenario 2 (yellow line) showed an increasing trend. Hence, there was an increasing trend in the domestic price of veneer and plywood, as the production of timber-based products increased. The other SFM practice scenarios failed to show any enhancement after the implementation of the SFM practice scenarios. After incorporating the 3 scenarios (light blue line), the forecast line (S4) failed to outweigh the baseline; it also revealed a higher forecast line than Scenarios 1 and 3.



Notes: The vertical line refers to the threshold between historical data and forecasted data.

FIGURES 3. Forecasting results on veneer and plywood production



Notes: The vertical line refers to the threshold between historical and forecasted data.

FIGURES 4. Forecasting results on veneer and plywood production

DISCUSSION OF FORECASTING RESULTS AMONG THE PRODUCTION OF THREE COMMODITIES

The forecasted results reveal that the trend for sawn timber production is constantly increasing, even after the imposition of the SFM practice scenarios. Hence, sawn timber production positively affected by SFM practices. The producers can enhance sawn timber production, even after imposing the SFM practice scenario if they are willing to bear the increasing costs and the raw materials shortage. This is due to the demand of sawn timber from both domestic and international markets. According to Shamsudin and Othman (1995), Malaysia plays a dominant role in the international sawn timber trade. In 2012, Malaysia was a major supplier of hard wood sawn timber, only falling behind Brazil and Cameroon (United Nation 2013).

The production of veneer and plywood is negatively affected by the SFM practice scenarios. The results suggest that producers decrease veneer and plywood production, due to SFM practices, since both commodities originated from the same mill. Consumers also consume veneer and plywood in making value added products, such as furniture. As such, they must import veneer and plywood due to national supply issues (Referred to Figure 1(a) and 1(b)).

CONCLUSIONS

SFM practices ensure that production is carried out in a sustainable manner. However, for primary timber-based products, it leads to a raw materials shortage, competitive prices and higher production costs. FM practices result in a decrease in veneer and plywood production. With scarce amounts of veneer and plywood, veneer and plywood furniture consumers import products. Even after the imposition of the SFM practice scenarios, the amount of sawn timber produced increased. Hence, sawn timber production can be successfully grown using SFM practices. Focus should be placed on SFM practices for the timber industry and the natural resources in Malaysia to survive. To balance the growth of the timber-based industry and forest resource sustainability, an optimization mechanism should be taken into consideration to enhance both the forest conservation and timber-based industry goals. Policy recommendation such as the price strategy in primary timber-based products should be developed in order to increase the revenue in timber-based sector. Price premium could be implemented on timber-based product to catch a certified timber-based product market. High market demands and good prices for certified timber-based products can help to pursue sustainable forest management standards and have been a key driver for improvements in forest management in the future. This policy reflected to the inelastic of domestic price in domestic demand model for primary timber-based products.

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